**Normalization results for pairs 9\_0.png\_9\_1.png from subset png\picture\_inside**

**9\_0.png: 9\_1.png: **

**Table 1 - Found homography parameters and normalization accuracy assessment**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original:  img1: 0 img2: 0 | h11 | h12 | h13 | h21 | h22 | h23 | h31 | h32 | h33 | avg ErrPar (param) | avg ErrIM (pixel) | max ErrIM | avg ErrCPM (corner) | max ErrCPM | Expert rate |
| SIFT | -0,012 | 0,46 | 44,517 | -0,384 | 0,097 | 529,566 | 0 | 0 | 1 | 0 | 0,281 | 2,472 | ~ | ~ |  |
| SURF128 | -0,012 | 0,464 | 44,243 | -0,387 | 0,105 | 529,873 | 0 | 0 | 1 | 0 | 0,71 | 2,688 | ~ | ~ |  |
| SURF64 | -0,011 | 0,467 | 43,681 | -0,385 | 0,112 | 529,928 | 0 | 0 | 1 | 0 | 0,816 | 3,315 | ~ | ~ |  |
| ORB | -0,01 | 0,465 | 44,051 | -0,38 | 0,103 | 529,885 | 0 | 0 | 1 | 0 | 0,687 | 3,025 | ~ | ~ |  |
| ORB1000 | -0,01 | 0,472 | 43,444 | -0,383 | 0,115 | 530,675 | 0 | 0 | 1 | 0 | 0,747 | 2,162 | ~ | ~ |  |
| BRISK | -0,013 | 0,461 | 44,616 | -0,385 | 0,099 | 529,011 | 0 | 0 | 1 | 0 | 0,621 | 2,127 | ~ | ~ |  |
| KAZE | -0,013 | 0,464 | 43,458 | -0,393 | 0,107 | 528,256 | 0 | 0 | 1 | 0 | 0,937 | 2,037 | ~ | ~ |  |
| AKAZE | -0,01 | 0,484 | 43,658 | -0,384 | 0,151 | 532,121 | 0 | 0 | 1 | 0 | 0,755 | 2,237 | ~ | ~ |  |
| Original matrix |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

where h11, h12, h13, h21, h22, h23, h31, h32, h33 - parameters of found homography matrix H\* or of original one H;   
avgErrPar - average error of found parameters, the accuracy of found homography matrix parameters with a preliminary minimax normalization of found and original matrices;  
avgErrIM - average error of inlier coordinate matching;  
inliers - correct matches; outliers - false matches;  
maxErrIM – maximum error of inlier coordinate matching;  
avgErrCPM - average error of corner point matching;  
maxErrCPM - maximum error of corner point matching;  
expert rate - experts assessment of normalization accuracy with a 5-point scale: 0 - normalization failed, 1 - insufficient, 2 - satisfactory, 3 - good, 4 – excellent.

**Table 2 - Quantitative evaluation of descriptors, precision and recall estimation (with found overlap)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Name | NP1 | NP2 | NM | NI | DP1 | DP2 | OP1 | OP2 | NPO1 | NPO2 | NMO | DPO1 | DPO2 | Precision | RecallO1 | Comments |
| SIFT | 1487 | 586 | 306 | 246 | 0,0062 | 0,0024 | 100 | 15,2587 | 1487 | 425 | 306 | 0,0062 | 0,0116 | 0,8039 | 0,1654 |  |
| SURF128 | 1749 | 800 | 142 | 117 | 0,0073 | 0,0033 | 100 | 15,2812 | 1749 | 387 | 142 | 0,0073 | 0,0106 | 0,8239 | 0,0669 |  |
| SURF64 | 1749 | 800 | 169 | 142 | 0,0073 | 0,0033 | 100 | 15,2787 | 1749 | 387 | 169 | 0,0073 | 0,0106 | 0,8402 | 0,0812 |  |
| ORB | 4488 | 2855 | 332 | 294 | 0,0187 | 0,0119 | 100 | 15,2729 | 4488 | 1639 | 332 | 0,0187 | 0,0447 | 0,8855 | 0,0655 |  |
| ORB1000 | 1000 | 994 | 106 | 100 | 0,0042 | 0,0041 | 100 | 15,3113 | 1000 | 496 | 106 | 0,0042 | 0,0135 | 0,9434 | 0,1 |  |
| BRISK | 1761 | 1007 | 158 | 149 | 0,0073 | 0,0042 | 100 | 15,2671 | 1761 | 534 | 158 | 0,0073 | 0,0146 | 0,943 | 0,0846 |  |
| KAZE | 715 | 352 | 30 | 24 | 0,003 | 0,0015 | 100 | 15,3138 | 715 | 217 | 30 | 0,003 | 0,0059 | 0,8 | 0,0336 |  |
| AKAZE | 589 | 266 | 32 | 26 | 0,0025 | 0,0011 | 100 | 15,035 | 589 | 168 | 32 | 0,0025 | 0,0047 | 0,8125 | 0,0441 |  |

where NP - number of found key points; NP1, NP2 - number of found key points for image1 and image2 respectively;  
NM - number of matches found with NNDR method, NM=NI+NO;  
NI - number of inliers found with RANSAC method;  
NO - number of outliers discarded with RANSAC method;   
DP - density of key points (per cent), DP= NP/(height x width) , height, width - vertical and horizontal image sizes respectively (pixels)  
DP1, DP2 - density of key points points for image1 and image2 respectively;  
OP1, OP2 - overlap percentage for image1 and image2 respectively;  
NPO1, NPO2 - number of found key points on overlap for image1 and image2 respectivelyy;  
NMO - number of matches on overlap found with NNDR method;  
DPO1, DPO2 - density of key points points on overlap for image1 and image2 respectively;   
OA - overlap area (pixels), OA1, OA2 - overlap area for image1 and image2 respectively;  
DPO1= NPO1/OA1; DPO2= NPO2/OA2;  
Precision = NI/ NM - the rate to evaluate the part of inliers to all found matches with NNDR method;  
RecallO1 = NI/ NPO1 - completeness of inlier retrieval relative to the number of all key points on overlap for image1. The rate illustrates usefulness of the found key points for normalization.

**Table 3 - Estimation of time costs**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Name | NP1 | NP2 | DesT1, sec | DesT2, sec | MatchT, sec | InlierT, sec | AvgDesT, ms | AvgMatchT, ms | AvgInlierT, ms | TotalNormT, sec |
| SIFT | 1487 | 586 | 0,047906 | 0,042765 | 0,007905 | 0,000554 | 0,052597 | 0,025834 | 0,002253 | 0,099131 |
| SURF128 | 1749 | 800 | 0,056136 | 0,035277 | 0,014142 | 0,0005 | 0,038095 | 0,099592 | 0,004276 | 0,106055 |
| SURF64 | 1749 | 800 | 0,053199 | 0,047181 | 0,008255 | 0,000486 | 0,044696 | 0,048845 | 0,003425 | 0,109121 |
| ORB | 4488 | 2855 | 0,014181 | 0,010981 | 0,03651 | 0,000486 | 0,003502 | 0,10997 | 0,001653 | 0,062157 |
| ORB1000 | 1000 | 994 | 0,009252 | 0,008479 | 0,003465 | 0,000278 | 0,008891 | 0,032684 | 0,002781 | 0,021474 |
| BRISK | 1761 | 1007 | 0,025726 | 0,014532 | 0,0059 | 0,000302 | 0,014519 | 0,037339 | 0,002027 | 0,046459 |
| KAZE | 715 | 352 | 0,113886 | 0,10709 | 0,002623 | 0,000528 | 0,231757 | 0,087426 | 0,021987 | 0,224127 |
| AKAZE | 589 | 266 | 0,019116 | 0,016455 | 0,001039 | 0,000555 | 0,047157 | 0,032458 | 0,021359 | 0,037165 |

where DesT – descriptor creation time (time for key point detection and descriptor computation), DesT1, DesT2 – creation time of descriptors for image1 and image2 respectively;  
MatchT - retrieval time of matching found with NNDR method for the pair;  
InlierT – inlier retrieval time found with RANSAC method for the pair;  
AvgDesT – average time for one descriptor creation;  
AvgMatchT - average time for one match retrieval with NNDR method;  
AvgInlierT – average time for one inlier retrieval with RANSAC method;  
TotalNormT – total normalization time for the pair.